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ANGRITE LEW87051: ARE THE OLIVINES PHENO'S OR XENO'S? A CONTINUING STORY.

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INTRODUCTION: The achondrite LEW87051 is a porphyritic basalt consisting of large subhedral to euhedral zoned olivines in a finer-grained groundmass. The texture of this groundmass looks remarkably like a quenched melt. However, although the rock is clearly igneous, its exact origins and history are under dispute. From petrographic observations, Prinz [1] felt that the large olivines were xenocrysts and that the zoning reflected interaction with an unrelated, CAI-enriched melt. McKay et. al [2,3,4] was able to model the olivines as phenocrysts, whose zoning was the result of a parent melt that changed in composition as material crystallized, eg., fractional crystallization in a closed system, and calculated a parent melt composition. Jurewicz and McKay [5] compared the calculated parent melt composition with actual partial melts from CV and CM chondrites. They showed that the calculated melt was substantially different from equilibrium melts of these chondrites; however, the LEW87051 groundmass composition [3] was similar to some of the low temperature partial melts, although slightly enriched in AN (or depleted in OL) components.

This study presents the results of an independent petrologic look at other olivines in LEW87051, and the preliminary results of a quantitative model for the major zoning in these olivines as diffusive-exchange with an olivine-saturated, low temperature angritic melt.

PETROGRAPHY: Figure 1 shows a photomicrograph of the euhedral grain which is the focus of this study. The long axis is nearly parallel to the c-axis of the crystal. The zoning is most developed along the long axis, and less developed perpendicular to that axis. EPMA analysis shows that this zoning is primarily in Fe, Mg and Mn, and that it transverses the "rim" and "main grain" sections of [4], as defined by molar $FeO/(FeO+MgO)$ ratios. Figure 2 gives details of the FeO gradient parallel to the c-axis, as determined by several EPMA traverses near the center of the grain. No high Cr central core equivalent to that observed by McKay et. al [4] was found in this particular cross-section. The Cr and Ca in the olivine was weakly zoned. Also, the Cr and Ca contents were higher and lower, respectively, than would be expected from equilibration with a low-temperature angritic groundmass ([4], this study).

EXPERIMENTAL: A 16 hour isothermal diffusive-exchange experiment [6] was slowly quenched (1185°C to 1000°C in ~20 minutes), and is shown in Figure 3. This charge qualitatively reproduces some of the general textural and chemical features (ie, gradients in Fe, Mg and Mn but not Ca or Cr) of olivine in LEW87051. The source melt for this experiment was chosen (based upon previous work in angritic systems [4],[7]) to simulate the groundmass of LEW87051 in that plagioclase was on the liquidus (~1195°C) but olivine was present at run conditions (1185°C, IW+1). A charge of this source melt was run for 7-days, and results from this equilibrium experiment were used to constrain the initial conditions needed for a diffusion model of the zoning in the LEW87051 olivines.

THE MODEL: The zoning in LEW87051 parallel to the c-axis was modeled assuming isothermal, composition-independent diffusion of cations from an infinite source (a melt of constant composition [6]) as a first approximation. Implicit to this model is that a compositional profile can be linearized by inversion through an error function. Accordingly, the FeO gradient of Figure 2 is shown inverted through an error function in Figure 4. In order to quantify this result, diffusion rates for Fe in olivine at the appropriate temperature and oxygen fugacity (first guess, ~1185°C, IW+1) were obtained from [6] and [8] and plugged into the model to obtain a residence time of $\leq$10 days for the olivine in the low temperature melt. This short residence time can also be shown to account for the observed Mg and Mn profiles, and the lack of Ca-rich and Cr-poor rims.

DISCUSSION AND CONCLUSIONS: The strong Fe, Mg, and Mn zoning in the olivines from LEW87051 are consistent with the rapid diffusional-exchange of cations with a low-temperature, angritic melt. The lack of strong zoning in Cr and Ca near the edge of the olivine that might otherwise be expected from contact with a low temperature angritic melt can be explained by slower Ca and Cr diffusion. Accordingly, the observed, weak gradients in Cr and Ca may be relict growth phenomenon from a higher temperature process such as that

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suggested by McKay *et. al [2,4]*. In fact, we note that, if the blocky crystal studied in *[4]* was cut perpendicualr to the c-axis, the diffusion profiles may have been so short that they became inconsequential to modeling the Fe/Mg profiles using fractional crystallization. (Although we are checking, it seems unlikely that the model of *[4]* becomes strikingly linear during inversion through the error function). Perhaps the large olivines are xenocrysts, equilibrating with a low-temperature angritic melt. Another possibility is that LEW87051 underwent two periods of melting: one where euhedral olivine crystallized and settled from a melt, followed by a second, short, low temperature melting event during which the strong Fe, Mg and Mn zoning was produced. A third possibility is that the crystals recall a single melting event with a nonlinear cooling history.

REFERENCES: [1] Prinz et at (1990) LPSC XXI 979-980; [2] McKay et. al (1990) LPSC XXI 771-772; [3] G.A. McKay (1989) 52th Met. Soc. Annual Meeting (oral presentation); [4] McKay et. al (1991) Meteoritics 26 370; [5] Jurewicz and McKay (1992) LPSC XXIII 643-644; [6] Jurewicz and Watson (1988) CMP 99 186-201; [7] McKay et. al (1988) LPSC XIX 760-761; [8] Buening and Buseck (1973) JGR 78:29 6852-6862.

Fig.1. SEM photomicrograph of LEW87051 showing the crystal being modeled (long axis //c) with major-element zoning, and "quench" texture of groundmass.
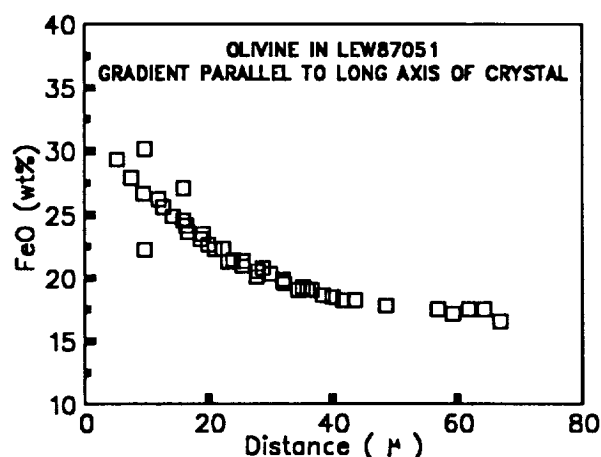

Fig.2. Change in FeO //c axis. The position of the Crystal-melt interface was determined visually. Data <5μ from interface was excluded.

| Slowly quenched melt | Olivine cube |

Fig.3. BEI photomicrograph of the diffusive-exchange experiment showing texture of the groundmass and zining in the olivine cube.
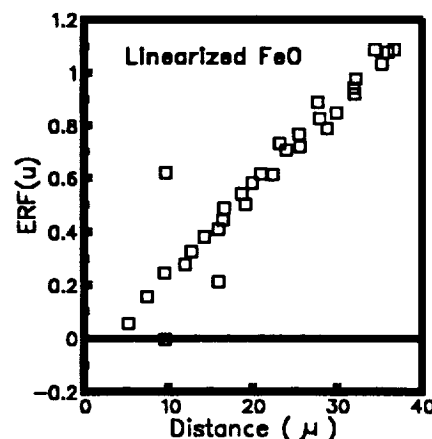

Fig. 4. Data from Fig. 1 inverted through the error function. The Y-intercept less than 0 indicates either an incorrect estimate of initial composition (<2% FeO) or a systematic error in position (~8 microns). In the system of [2,4], the olivine changes ~2wt% FeO in 10-20°C.

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